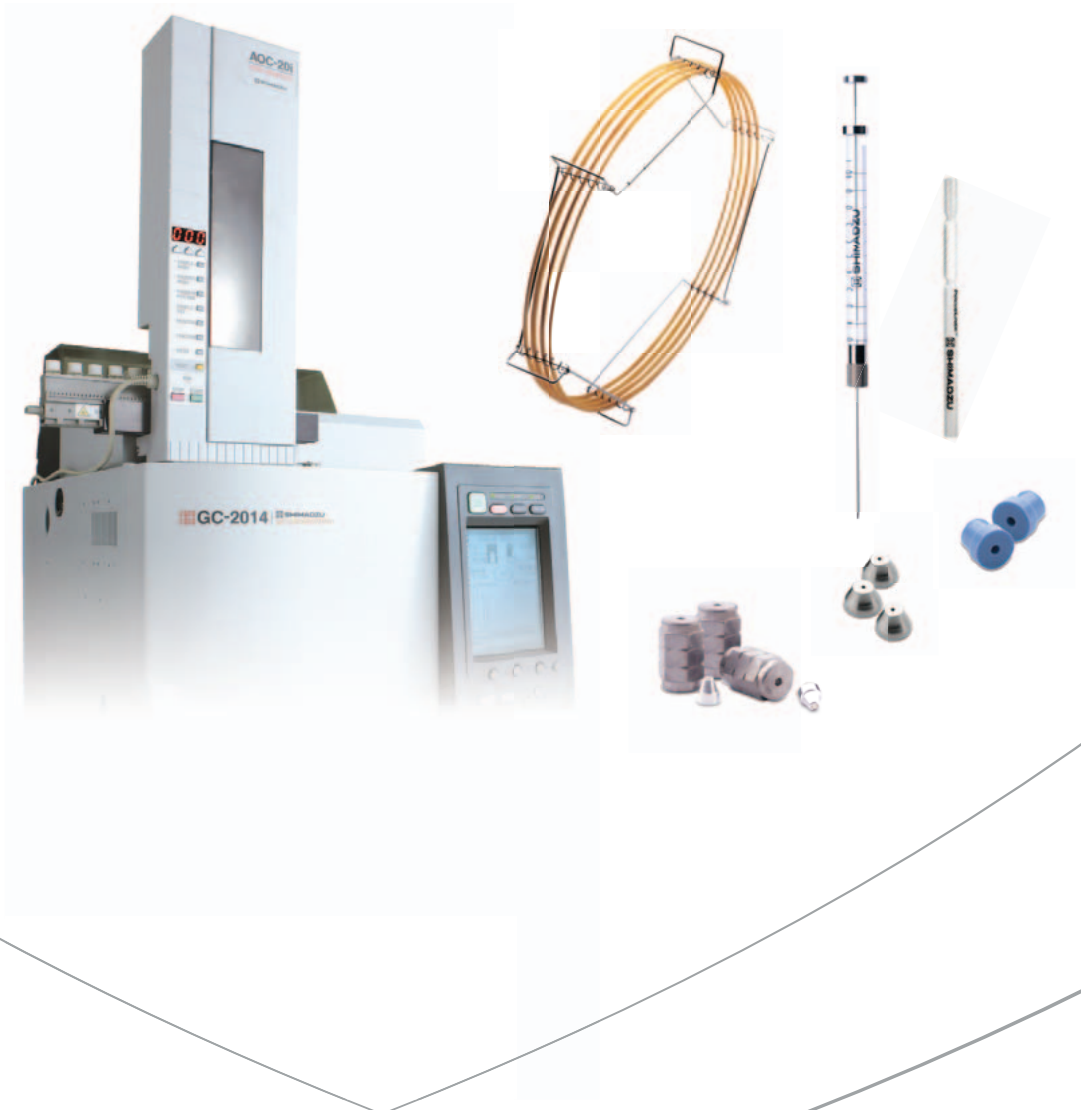
C184-E033

SHIMADZU
Excellence in Science

GC Consumables Product Guide




AOC-20i
GC-2014
SHIMADZU

GC Consumables Product Guide

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GC CONSUMABLES

GC Consumables are designed to complement your Shimadzu GC-2010 and GC-2014 System. Shimadzu understands your chromatography analysis does not end with the selection of the GC column - the combination of components selected for your instrument make an important contribution to successful chromatography. Shimadzu GC Consumables are designed to provide you with the best separation possible.

SAMPLE INTRODUCTION – Syringes

Shimadzu's syringes for both manual and autosampler use incorporate Diamond Syringe Technology offering significantly improved levels of durability, clarity and accuracy. Features of the Diamond Syringe Technology include:

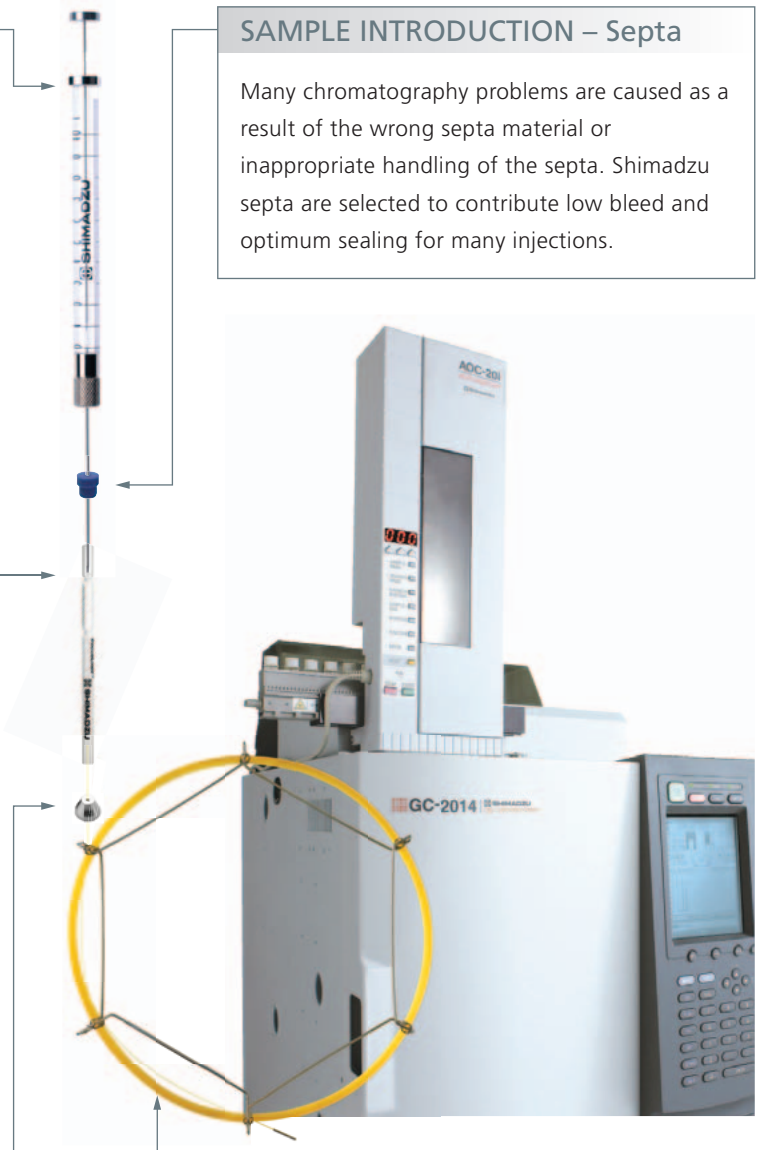
- Longest working life in the industry
- Improved solvent resistance
- Greater operational temperature range
- Reduced dead volume and carryover

SAMPLE INTRODUCTION – GC Inlet Liners

The GC inlet liner is where the sample is introduced and vaporized into the gaseous phase. The geometry of each of Shimadzu's inlet liners is important and the correct choice of inlet liner can significantly improve the performance of the chromatography. Inlet liner deactivation, quartz wool quantity and position are essential to ensure reproducible and accurate sample introduction for each sample type.

SEPARATION – GC Connections (Ferrules and Unions)

Shimadzu provides an array of connection types for use in the GC, each selected to ensure the best connection solution is achieved. The correct selection of the connection type will eliminate dead volumes, leaks during temperature cycling and problems with mismatched tubing sizes.



SAMPLE INTRODUCTION – Septa

Many chromatography problems are caused as a result of the wrong septa material or inappropriate handling of the septa. Shimadzu septa are selected to contribute low bleed and optimum sealing for many injections.

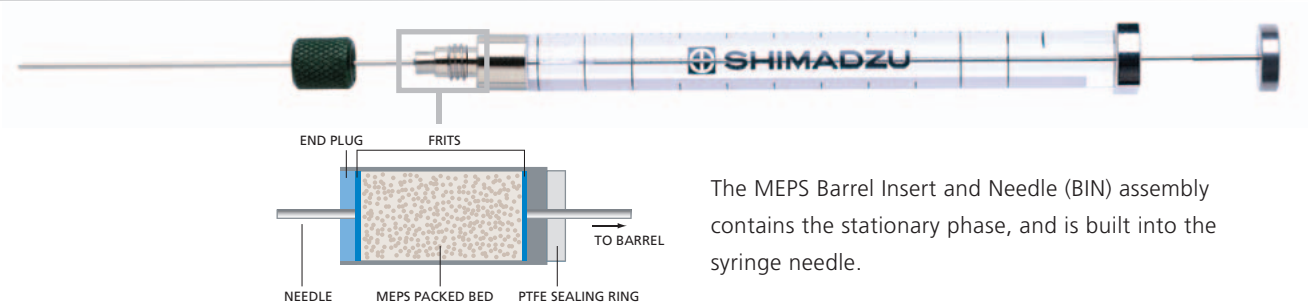
SEPARATION – GC Capillary Columns

Shimadzu offers a range of stationary phases including non-polar and polar functionalities.

SAMPLE PREPARATION – MEPS™

MEPS™ is Micro Extraction by Packed Sorbent and is a development for sample preparation and handling. MEPS is the miniaturization of conventional SPE packed bed devices from milliliter bed volumes to microliter volumes. The MEPS approach to sample preparation is suitable for reversed phases, normal phases, mixed mode or ion exchange chemistries. MEPS is available in a variety of common SPE phases.

MEPS BARREL INSERT AND NEEDLE



The MEPS Barrel Insert and Needle (BIN) assembly contains the stationary phase, and is built into the syringe needle.

SAMPLE SIZE AND SENSITIVITY

Sample volumes may be as little as 10 µL, or by taking multiple aliquots of 100 µL or 250 µL, samples of 1 mL or larger may be concentrated.

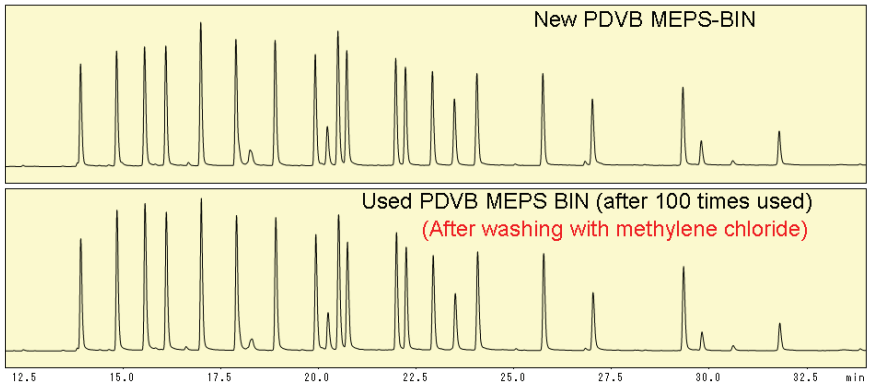
AUTOMATION

Extract samples and make injections on-line using a single device, reducing sample processing times and the need for operator intervention.

SORBENT LIFE

BIN life is dependent on the specific matrix being analyzed. For example, C18 analysis of whole plasma samples is conservatively 25-100 samples before the BIN needs to be changed. BIN life of cleaner samples is significantly longer.

Chromatogram of 22 pesticides standard solution (40 ng/mL)



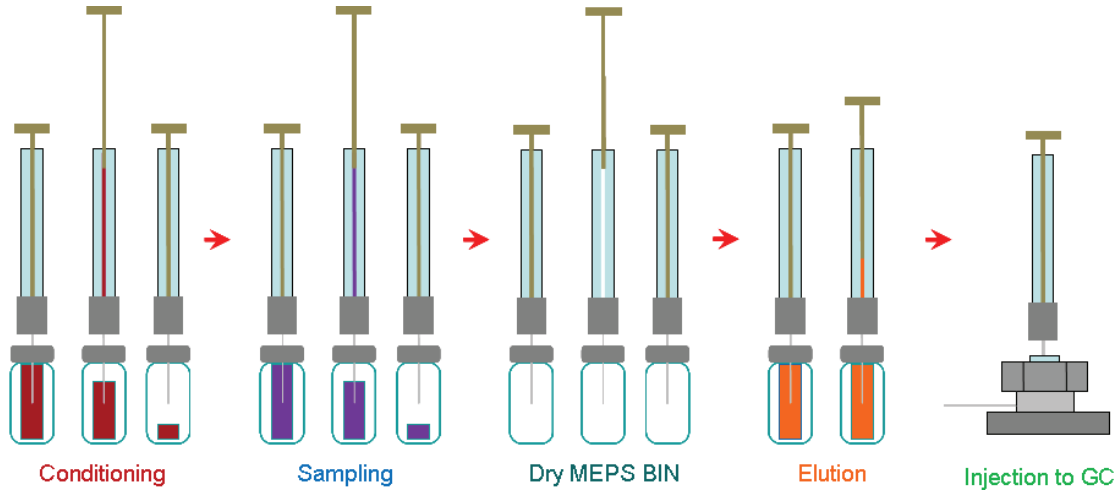
CARRYOVER

The small quantity of phase in the MEPS BIN is easily and effectively washed between samples to reduce the possibility of carryover. This washing process is not practical with off-line SPE devices. With automation of MEPS, washing occurs while the previous sample is running.

FLEXIBLE AND EASY TO USE

The dimensions of the sorbent bed ensure performance remains identical to conventional SPE devices when used for extraction of similar samples. The AOC-MEPS system was developed to incorporate MEPS into a process automation workflow, combining sample preparation and analysis in a single platform

AOC-MEPS System



When automated by AOC-MEPS system, the injection volume is much larger compared to the commonly used GC injection volumes of 1 - 2 µL. With AOC-MEPS, the typical injections are 50 to 200 µL of elution solvent into the analytical instrument.

A large volume injection volume technique should be employed that removes the solvent volume from inside the injector unit while condensing the target compounds.

PTV Inlet Liner for AOC-MEPS System (AOC-20i + GC-2010 + PTV configuration)

OD (mm)	ID (mm)	Length (mm)	P/N
3.5	2.5	95	221-74830-09

AOC-20i

MEPS™ Syringe for AOC-20i

Syringe Volume	PTFE Tipped Plunger	Needle Length (mm)	Needle Gauge	Needle OD (mm)	Needle ID (mm)	Needle Tip	P/N	Spare Parts	P/N
100 µL	✓						**221-74830-01**	Plunger Pk 1	221-74830-10

Phase	Qty per pack	P/N
C18	5	**221-74830-03**
Silica	5	**221-74830-04**
C8 + SCX	5	**221-74830-05**
C2	5	**221-74830-06**
C8	5	**221-74830-07**
PDVB	5	**221-74830-02**
SDVB	5	**221-74830-11**
HDVB	5	**221-74830-12**
Development Kit - contains 1 each of C18, C8, Silica, C8+SCX, C2	1 of each phase	**221-74830-08**

AOC-5000

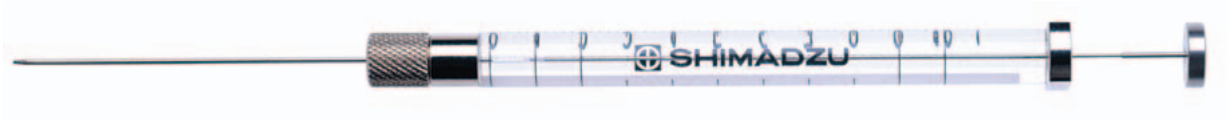
MEPS™ Syringes for AOC-5000

Syringe Volume	PTFE Tipped Plunger	Needle Length (mm)	Needle Gauge	Needle OD (mm)	Needle ID (mm)	Needle Tip	P/N	Spare Parts	P/N
100 µL	✓						**221-75202-01**	Plunger Pk 1	221-75202-03
250 µL	✓						**221-75202-02**	Plunger Pk 1	221-75202-04

Phase	Qty per pack	MEPS for 100 µL Syringe P/N	MEPS for 250 µL Syringe P/N
C18	5	**221-75198-01**	**221-75199-01**
Silica	5	**221-75198-02**	**221-75199-02**
C8 + SCX	5	**221-75198-03**	**221-75199-03**
C2	5	**221-75198-04**	**221-75199-04**
C8	5	**221-75198-06**	**221-75199-06**
Development Kit - contains 1 each of C18, C8, Silica, C8+SCX, C2	1 of each phase	**221-75198-05**	**221-75199-05**

SAMPLE INTRODUCTION – Syringes

Shimadzu Diamond syringes are the result of technological advancements in materials, design, and engineering. Designed to meet the ever increasing levels of sensitivity required by today's analyses, Shimadzu Diamond syringes give you a new level of accuracy and precision.



LONGER LIFE

Shimadzu Diamond syringes have a longer life. The improved solvent resistance and maximized operational temperature range along with the smoothest available internal glass surface ensure you receive the longest lifetime from your Shimadzu syringe.

SUPERIOR PERFORMANCE AND ROBUSTNESS

Shimadzu Diamond syringes have superior performance and robustness with unsurpassed levels of operational strength and durability. Potential for contamination is significantly reduced by the near-zero syringe dead volume and minimized adhesive in the flow path.

REDUCED CARRYOVER

Engineering enhancements have eliminated areas where fluid can become trapped and potentially cause carryover, improving accuracy, precision and analysis results.

Manual Autosampler or Instrument Syringes

If a syringe is being used by hand, a manual syringe should be selected. If a syringe is installed in an AOC autosampler then choose the appropriate syringe and volume to suit your instrument and application.

Shimadzu autosampler syringes are specifically designed to meet instrument dimensional specifications, have an accuracy of better than ± 1 % and are designed for precise, worry-free overnight sampling.

Needle Tip Styles

Cone: GC Autosampler

The cone shaped needle tip is specially developed to withstand multi injection demands and improve septum lifetime when used with the AOC autosampler. The cone design effectively "parts" the septum during piercing instead of cutting it, as would a bevel needle.

Bevel: Manual GC

The standard general purpose needle tip style supplied with many Shimadzu syringes is a 20 ° bevel tip. It is the preferred option for manual injection where piercing the septum in exactly the same place is difficult. The bevel tip is designed for optimum septum penetration and prevention of septum coring.

Dome:

This style needle is recommended for use with predrilled septa. The tip is rounded and polished to help septum penetration.

LC: HPLC

These needles are used for LC and HPLC valve injection and have a 90 ° square tip with rounded and polished edges. This eliminates damage to the valve's rotor seal and stator face. This needle tip style is a good choice for general liquid dispensing.

Side Hole Dome:

Samples are filled and dispensed through the side hole eliminating septum plugging of the needle. Ideal for large volume gas injection. The solid domed tip minimizes septum damage.

Valves

OPEN ⟷ CLOSE

The push-button valve attaches directly to any luer lock 1 mL – 100 mL Shimadzu syringe.

OPEN ⟷ CLOSE

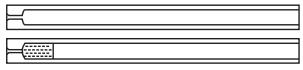
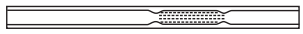
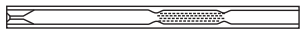
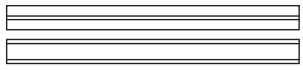
The push-button valve attaches to any luer lock 5 mL – 100 mL Shimadzu syringe.

Syringe Volume	PTFE Tipped Plunger	Needle Length (mm)	Needle Gauge	Needle OD (mm)	Needle ID (mm)	Needle Tip	P/N	Spare Parts	P/N
Syringes for AOC-20i									
5 µL		42	23	0.63	0.11	Cone	**221-75173**		
10 µL	✓	42	23	0.63	0.11	Cone	**221-74469**	Plunger Pk 2	221-75173-01
10 µL		42	23	0.63	0.11	Cone	**221-34618**		
10 µL		42	23 – 26	0.63 – 0.47	0.11	Dome	**221-37282-02**		
10 µL	✓	42	23	0.63	0.11	Cone	**221-75174**	Plunger Pk 2	221-75174-02
								Needle Pk 2	221-75174-01
50 µL		42	23	0.63	0.24	Cone	**221-45243**		
250 µL	✓	42	23	0.63	0.24	Cone	**221-45244**	Plunger Pk 2	221-45244-01
MEPS™ Syringe for AOC-20i									
100 µL	✓						**221-74830-01**	Plunger Pk 1	221-74830-10
Syringes for AOC-5000									
10 µL		50	26	0.47	0.11	Cone	**221-75175**		
10 µL		50	23	0.63	0.11	Cone	**221-75175-01**		
10 µL		80	26	0.47	0.11	Cone	**221-75176**		
10 µL		80	23	0.63	0.11	Cone	**221-75176-01**		
10 µL	✓	50	26	0.47	0.11	Cone	**221-75175-02**		
10 µL	✓	50	23	0.63	0.11	Cone	**221-75175-03**		
25 µL	✓	50	23	0.63	0.24	Cone	**221-75177**		
1 mL	✓	50	26	0.47	0.15	Side-Hole Dome	**221-75178**		
1 mL	✓	50	23	0.63	0.15	Side-Hole Dome	**221-75178-01**		
2.5 mL	✓	50	26	0.47	0.15	Side-Hole Dome	**221-75179**		
2.5 mL	✓	50	23	0.63	0.15	Side-Hole Dome	**221-75179-01**		
MEPS™ Syringes for AOC-5000									
100 µL	✓						**221-75202-01**	Plunger Pk 1	221-75202-03
250 µL	✓						**221-75202-02**	Plunger Pk 1	221-75202-04
Manual Syringes									
5 µL		50	26	0.47	0.11	Bevel	**221-75170**		
10 µL		50	26	0.47	0.11	Bevel	**670-12552-01**		
10 µL	✓	50	26	0.47	0.11	Bevel	**221-75170-01**	Plunger Pk 2	221-75170-02
10 µL		51	22	0.028"	0.17	LC	**670-12554-01**		
25 µL		50	25	0.5	0.2	Bevel	**670-12510-31**		
25 µL	✓	50	25	0.5	0.2	Bevel	**221-75171**	Plunger Pk 1	221-75171-01
25 µL		51	22	0.028"	0.37	LC	**670-12554-02**		
50 µL		50	25	0.5	0.2	Bevel	**670-12510-36**		
50 µL	✓	50	25	0.5	0.2	Bevel	**221-75172**	Plunger Pk 1	221-75172-03
50 µL		51	22	0.028"	0.37	LC	**670-12554-03**		
100 µL		50	25	0.5	0.2	Bevel	**670-12510-18**		
100 µL	✓	50	25	0.5	0.2	Bevel	**221-75172-01**	Plunger Pk 1	221-75172-04
100 µL		51	22	0.028"	0.37	LC	**670-12554-04**		
250 µL		50	25	0.5	0.2	Bevel	**670-12510-19**		
250 µL	✓	50	25	0.5	0.2	Bevel	**221-75172-02**	Plunger Pk 1	221-75172-05
250 µL		51	22	0.028"	0.37	LC	**670-12554-05**		
500 µL		50	25	0.5	0.2	Bevel	**670-12510-20**		
500 µL		51	22	0.028"	0.37	LC	**670-12554-06**		
1 mL	✓	Luer Lock					**221-54778-01**	Plunger Pk 1	221-54778-11
5 mL	✓	Luer Lock					**221-54778-02**	Plunger Pk 1	221-54778-12
10 mL	✓	Luer Lock					**221-54778-03**	Plunger Pk 1	221-54778-13
25 mL	✓	Luer Lock					**221-54778-04**	Plunger Pk 1	221-54778-14
50 mL	✓	Luer Lock					**221-54778-05**	Plunger Pk 1	221-54778-15
100 mL	✓	Luer Lock					**221-54778-06**	Plunger Pk 1	221-54778-16
Luer Lock Needles									
		50	23	0.63	0.32	Bevel	**221-54778-51**		
		50	19	1.07	0.65	Bevel	**221-54778-52**		
		50	14	2.1	1.6	Bevel	**221-54778-54**		
Syringe Valves									
5 mL to 100 mL		Luer Lock					**221-54778-49**		
1 mL to 100 mL		Luer Lock					**221-54778-50**		

SAMPLE INTRODUCTION – GC Inlet Liners

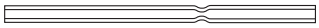
The GC inlet functions as the interface between the syringe and the GC capillary column, where the sample is introduced, vaporized, mixed with carrier gas and transferred to the column. Shimadzu instruments offer several types of inlets - split, splitless, programmable temperature vaporization (PTV) and on-column.

The inlet liner prevents the sample contacting the metal walls of the injector block. Inlet liner geometry and packing materials enable the inlet liner to achieve greater heated surface area; this additional surface area can often improve sample vaporization. Conversely, choosing the wrong inlet liner geometry can significantly decrease the reproducibility and quality of analysis.

Injection Technique	Sample Types	Inlet Liner Geometry	Function
Splitless	Trace Level Analyses/ Active Compounds	Taper 	A bottom taper focuses sample onto the head of the column and minimizes sample contact with metal parts of the inlet. The addition of quartz wool to your inlet liner promotes mixing of analytes, aids the vaporization of liquid samples, and works as a trap to collect non-volatile residue in the sample (i.e. protects capillary column from 'dirty' samples).
Split	General Purpose/ Concentrated Samples/ Dirty Samples	FocusLiner™ 	Ensures quartz wool remains in the correct position in the liner. Excellent reproducibility results from the wiping of the sample from the syringe needle and the prevention of droplet formation. Minimizes high molecular weight discrimination.
Splitless	Trace Level Analyses/ Dirty Samples/ Wide Boiling Point Range	Taper FocusLiner™ 	Bottom taper focuses sample onto the head of the column and minimizes contact with metal parts of the inlet. Excellent reproducibility results from the wiping of the sample from the syringe needle and the prevention of droplet formation. Minimizes high molecular weight discrimination.
Direct	Trace Level Analyses/ Active Compounds	Direct Taper 	Direct inlet liners facilitate maximum transfer of sample by connecting directly to the GC column and inhibiting sample degradation due to hot metal components inside inlet.
Split/Splitless	General Purpose/ Concentrated Samples/ Dirty Samples (only if quartz wool is present)/ Gaseous Samples (also purge & trap, headspace)	Straight 	Straight inlet liners facilitate higher split flows. Narrow bore straight inlet liners facilitate fast GC work. Small injection volumes of less than 0.5 µL are best used with a narrow bore. Narrow bore straight inlet liners improve focussing of gaseous samples (purge, trap & headspace).

Inlet Liner Deactivation

Every batch of inlet liners are tested for inertness using the EPA 8081B method. This standard method ensures that each batch of inlet liners has less than 3 % Endrin breakdown from a 1 ppm injection.

Description & Geometry Sketch	OD (mm)	ID (mm)	Length (mm)	Pack Size	P/N
GC-2010					
LINERGC20103.4MMIDGNWWOOLPKT5 	5.0	3.4	95	5	**221-75193**
LNRGC20103.4MMIDGNPKT5 	5.0	3.4	95	5	**221-75194**
GC-2014					
LNRGC20143.4MMIDGNPKT5 	5.0	3.4	95	5	**221-41444-05**
LNRGC20142.6MMIDPKT5 	5.0	2.6	95	5	**221-41544-05**
LNRGC20142.6MMIDTAPPKT5 	5.0	2.6	95	5	**221-41599-05**
LINERGC20143.4MMIDWWOOLGNPKT5 	5.0	3.4	95	5	**221-75195**
GC-2010/GC-2014					
LNRGC2010/20143.4MMIDTAPFOC(ontowool)PKT5 	5.0	3.4	95	5	**221-75187**
LNRGC2010/20143.4MMIDFOC(ontowool)PKT5 	5.0	3.4	95	5	**221-75188**
LNRGC2010/20143.4MMIDFOC(intowool)PKT5 	5.0	3.4	95	5	**221-75189**
LNRGC2010/20143.4MMIDPKT5(StraightThrough) 	5.0	3.4	95	5	**221-75190**
LNRGC2010/20143.4MMIDTAPFOC(intowool)PKT5 	5.0	3.4	95	5	**221-75191**
LNRGC2010/2014SINGLETAPPKT5 	5.0	3.4	95	5	**221-75192**
LNRGC2010/20140.75MMIDSPMEPKT5 	5.0	0.75	95	5	**221-75196**
GLASSINSERTSPLITLESS/WBIWWOOLPKT5 	5.0	3.4	95	5	**221-75197**

SAMPLE INTRODUCTION – Septa

- High temperature silicone
- Excellent durability, resealing and solvent and tear resistant
- Injection temperature up to 350 °C

Septum Type	Description	Pack Size	P/N
GC-2010/GC-2014			
Enduro Blue	High thermal stable material in blue color	50	221-75180

SAMPLE INTRODUCTION – Accessories

Additional Accessories

Description	P/N
Capillary Ceramic Tube Cutter (3 pc)	221-75181
Stainless Steel Nut/ SSNE-16-012S (Pk 5)	670-11009

SEPARATION - Connections

Ferrules are available in a variety of different materials, shapes and sizes depending on their use, the instrument and the size of the capillary column being used. Probably the most important but difficult aspect of choosing a ferrule is the selection of the material type. The table below will help you choose the appropriate ferrule material for your application.

When choosing ferrules ensure you consider the following:

1) The material that best suits your application.
2) The connection type you want.

The following selection table will assist with your decision.

Ferrule Material Type	Graphite	Graphite Vespel®	SilTite™ Metal
			
Features	• Easy to use. • Forms a stable seal. • Soft material. • Porous to oxygen. • Can be reused. • Forms a soft grip with capillary column. • Low emissions.	• A composite of graphite and Vespel®. • Mechanically robust. • Hard material, long lifetime. • Forms a strong grip with capillary column. • Cannot be reused with another capillary column. • Requires re-tightening.	• Specifically developed to overcome the problems associated with the use of 100% graphite and composite ferrules. • Strong seal on capillary columns. • Leak free - The ferrule and nut expand and contract at the same rate eliminating any chance of leaks with temperature cycling. • Nut does not need re-tightening after initial temperature cycles.
Suitable Uses	• Column to injector connection. • Non-mass spectrometer detectors (FID, ECD, TCD and NPD).	MS interfaces, although even with a good seal will leak air compared to SilTite™ ferrules.	Ideal for MS interfaces due to leak free seal.
Not Suitable For	Connecting columns to mass spectrometers, as porous to oxygen.	High temperature applications.	
Risks	• Can leave residue inside your column. • Can extrude into the injector or detector if it is over-tightened.	If not re-tightened after installation and temperature cycles of the GC, air may enter the column or detector decreasing sensitivity of the analysis and possibly degrading the column as well as components of the system.	Over-tightening of the seal can introduce leaks into the system. Follow the recommended installation instructions to avoid this problem.
Operating Temperature	Upper limit of 450 °C	Upper limit of 325 °C	No temperature limit in GC use.

Ferrule Material Type	Ferrule Code/ Description	Pack Size	P/N
Graphite	GFF-505-050	10	221-75182
Graphite Vespel®	GVF16-005	10	670-15003-04
	GVF16-008	10	670-15003-07
	GVF16-004	10	670-15003-03
Metal	SilTite™ 0.25 mm ID Column	10	221-72563-04
	SilTite™ 0.32 mm ID Column	10	221-72563-05
	SilTite™ 0.53 mm ID Column	10	221-72563-08
	SilTite™ 1/32" ID Column	10	221-75200-04
	SilTite™ Kit 10/32" 0.25 mm ID Column	1	221-75200
	SilTite™ Kit 10/32" 0.32 mm ID Column	1	221-75200-01
	SilTite™ Kit 10/32" 0.53 mm ID Column	1	221-75200-02
	SilTite™ Kit 1/32" ID Column	1	221-75200-03
	SilTite™ Nut 10/32" 0.8 mm ID Column	5	221-75186

SEPARATION - GC CAPILLARY COLUMNS

The Shimadzu GC capillary column range includes a variety of phases suitable for general purpose through to specific GC and GC-MS applications.

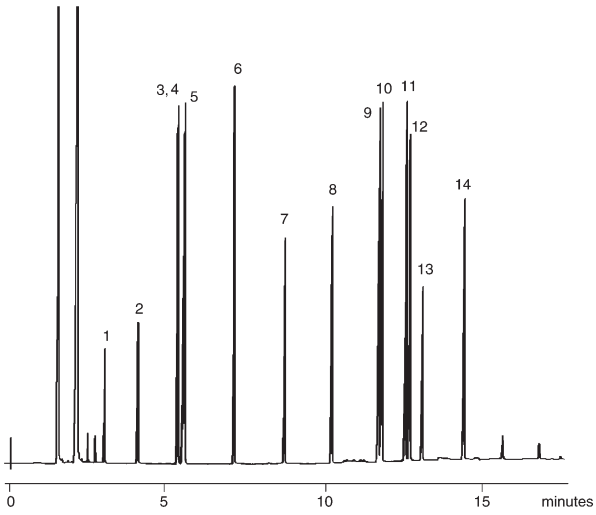
Shimadzu GC columns undergo rigorous testing to ensure they provide you with the best separation possible. Every GC column is tested at the maximum operating temperature for the column, and specific tests are undertaken based on the application the column is targeted for. This means you can be confident of a reliable separation, column after column.

CBP-1: 100% Dimethyl Polysiloxane; Classic Crosslinked Dimethyl Polysiloxane Technology

- Excellent general purpose non-polar GC column
- Suitable for all routine analyses
- 320 – 340 °C upper temperature limit – dependent on film thickness

ID (mm)	Film Thickness (µm)	Length (m)	Temperature Limits (°C)	P/N
0.22	0.25	25	-60 to 320/340	221-28635-25
0.22	0.25	50	-60 to 320/340	221-28635-50
0.1	0.1	12	-60 to 320/340	221-28651-12
0.32	0.5	25	-60 to 320/340	221-28639-25
0.32	0.5	50	-60 to 320/340	221-28639-50
0.53	1.0	12	-60 to 320/340	221-28647-12
0.53	1.0	25	-60 to 320/340	221-28647-25
0.53	5.0	12	-60 to 320/340	221-28648-12
0.53	5.0	25	-60 to 320/340	221-28648-25
0.53	5.0	50	-60 to 320/340	221-28648-50

Analysis of Dimethyl Esters of Dicarboxylic Acids on CBP-1



Column : CBP1-M25-025 (M = 0.22 mm ID)
Shimadzu P/N : 221-28635-25
Detector : FID

Components

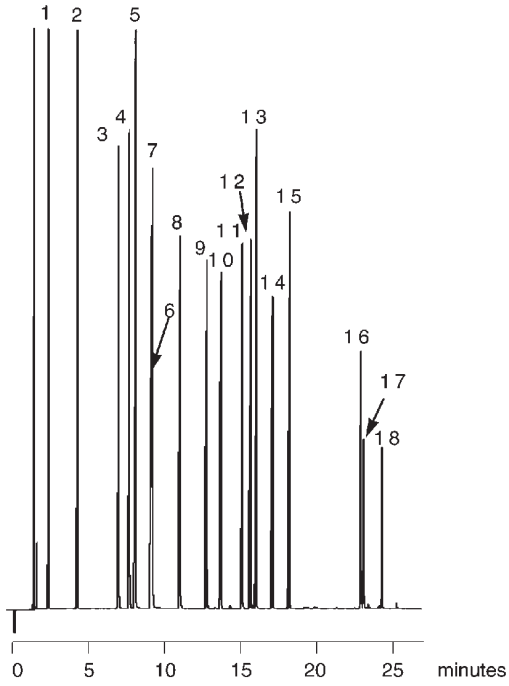
1. Dimethyl Oxalate
2. Dimethyl Malonate
3. Dimethyl Fumarate
4. Dimethyl Succinate
5. Dimethyl Maleate
6. Dimethyl Glutarate
7. Dimethyl Adipate
8. Dimethyl Pimelate
9. Dimethyl Suberate
10. Dimethyl Phthalate
11. Dimethyl Terephthalate
12. Dimethyl iso-Phthalate
13. Dimethyl Azelate
14. Dimethyl Sebacate

CBP-5: 5% phenyl / 95% Dimethyl Polysiloxane

- Ideal general purpose non-polar column
- Excellent inertness
- Good thermal stability

ID (mm)	Film Thickness (µm)	Length (m)	Temperature Limits (°C)	P/N
0.22	0.25	25	-60 to 320/340	**221-28636-25**
0.22	0.25	50	-60 to 320/340	**221-28636-50**
0.32	0.5	25	-60 to 320/340	**221-28641-25**
0.32	0.5	50	-60 to 280/300	**221-28641-50**

Analysis of Substituted Aromatics on CBP-5



Column : CBP5-M25-025
Shimadzu P/N : 221-28636-25
Detector : FID

Components

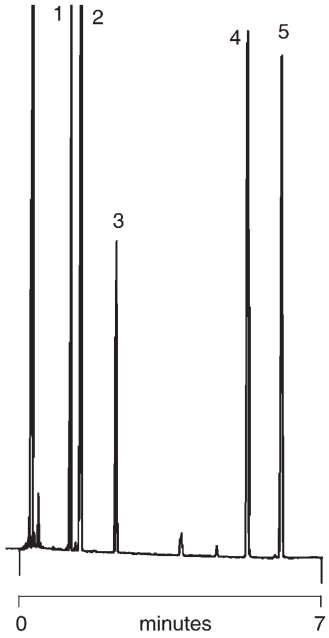
1. Benzene
2. Toluene
3. Chlorobenzene
4. Ethylbenzene
5. m, p-Xylene
6. o-Xylene
7. Styrene
8. iso Propylbenzene
9. n-Propylbenzene
10. 1,3,5-Trimethylbenzene
11. 1,2,4-Trimethylbenzene
12. m-Dichlorobenzene
13. sec-Butylbenzene, p-Dichlorobenzene
14. o-Dichlorobenzene
15. Butyl-benzene
16. 1,2,4 - Trichlorobenzene
17. Napthalene
18. Hexachlorobutadine

CBP-10: 14% Cyanopropylphenyl Polysiloxane

- Used for organochlorine pesticides analysis
- Bonded and crossed-linked
- Able to be solvent rinsed

ID (mm)	Film Thickness (µm)	Length (m)	Temperature Limits (°C)	P/N
0.1	0.1	12	-20 to 280/300	**221-28652-12**
0.22	0.25	25	-20 to 280/300	**221-28637-25**
0.22	0.25	50	-20 to 280/300	**221-28637-50**
0.32	0.50	25	-20 to 280/300	**221-28643-25**
0.32	0.50	50	-20 to 280/300	**221-28643-50**
0.53	1.0	12	-20 to 260/280	**221-28649-12**
0.53	1.0	25	-20 to 260/280	**221-28649-25**

Analysis of Haloethers on CBP-10



Column : CBP10-W12-100
Shimadzu P/N : 221-28649-12
Detector : FID

Components

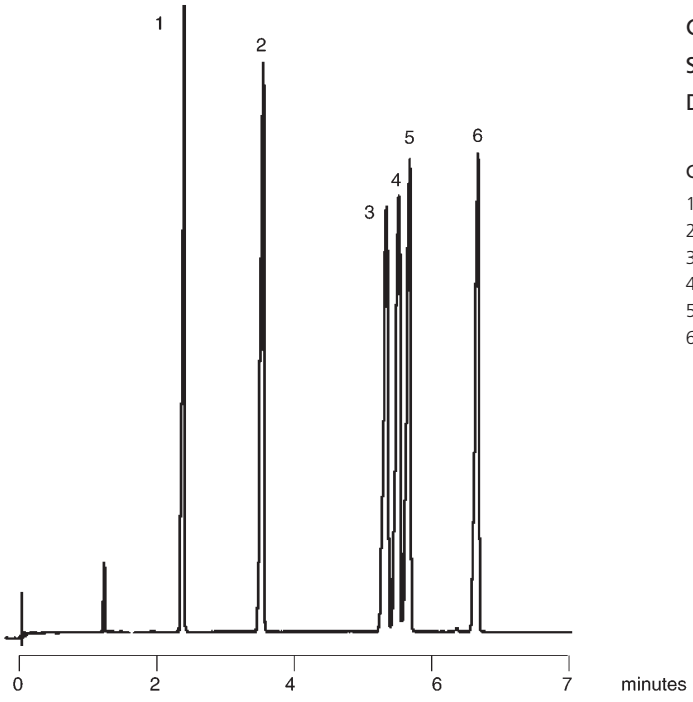
1. Bis (2-chloroethyl) ether
2. Bis (2-chloroisopropyl) ether
3. Bis (2-chloroethoxy) methane
4. 4-Chlorophenyl ether
5. 4-Bromophenyl ether

CBP-20: Bonded Polyethylene Glycol (Wax)

- Industry standard wax column
- Low bleed
- Polar phase suitable for hydrogen bonding analytes

ID (mm)	Film Thickness (µm)	Length (m)	Temperature Limits (°C)	P/N
0.22	0.25	25	20 to 260/280	**221-28638-25**
0.22	0.25	50	20 to 260/280	**221-28638-50**
0.32	0.50	25	20 to 260/280	**221-28645-25**
0.32	0.50	50	20 to 260/280	**221-28645-50**
0.53	1.0	12	20 to 260/280	**221-28650-12**
0.53	1.0	25	20 to 260/280	**221-28650-25**

Analysis of Aromatic Pollutants in Water on CBP-20



Column : CBP20-W25-100
Shimadzu P/N : 221-28650-25
Detector : FID

Components

1. Benzene
2. Toluene
3. Ethylbenzene
4. p-Xylene
5. m-Xylene
6. o-Xylene

CBP1-PONA

- Designed for the analysis of petroleum products
- Non-polar phase for PONA analysis
- Detailed hydrocarbon analysis according to ASTM (DHA-method)

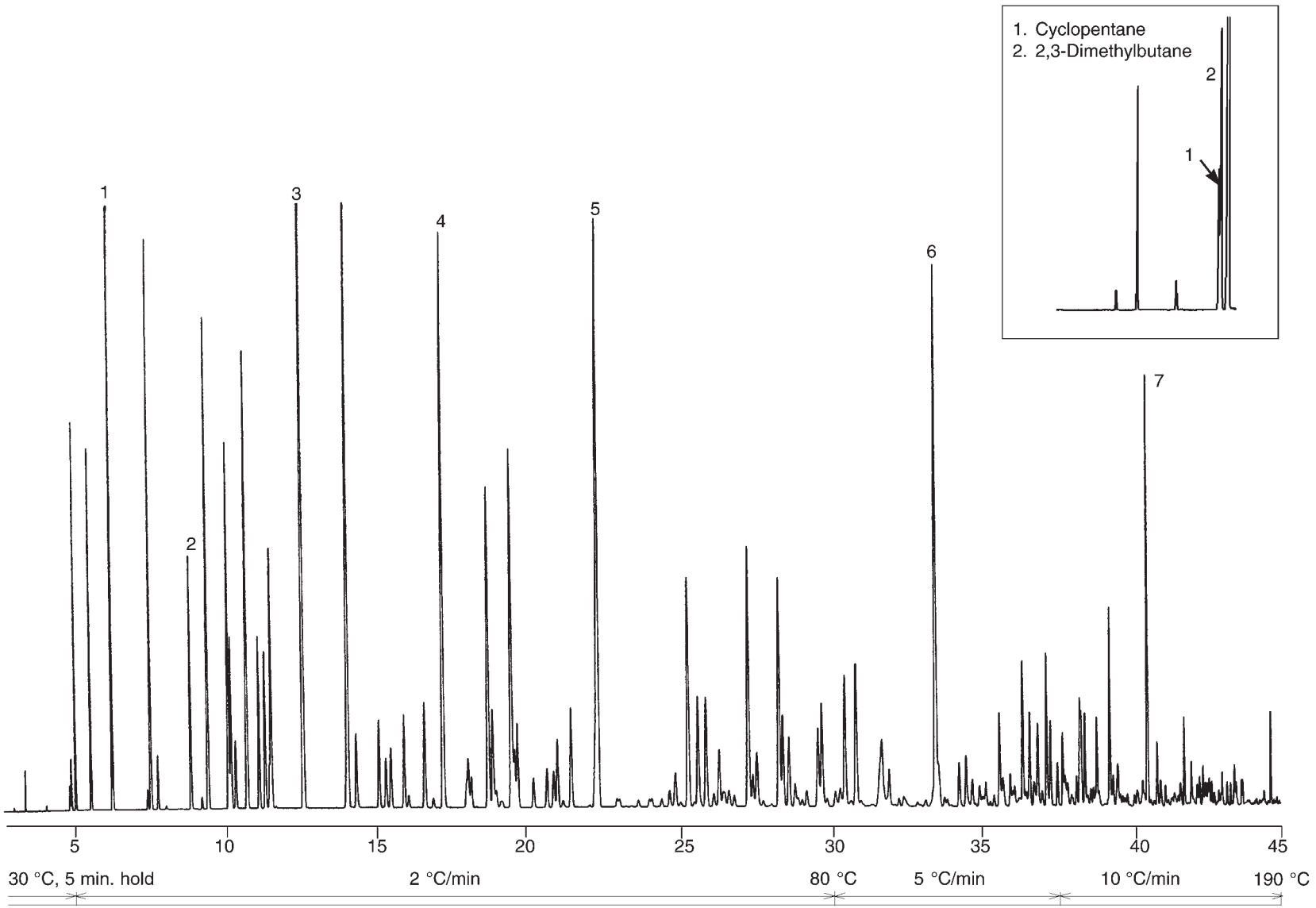
ID (mm)	Film Thickness (µm)	Length (m)	Temperature Limits (°C)	P/N
0.15	0.50	50	-60 to 320/340	**221-44082-50**

Analysis of Gasoline Range Hydrocarbons on CBP1-PONA

Column : CBP1-PONA
Shimadzu P/N : 221-44082-50
Detector : FID

Components

	TIME	COMPOUND
	4.85	Cyclopentane
	5.00	2,3-Dimethylbutane
	5.25	2-Methylpentane
	5.74	3-Methylpentane
1	6.45	n-Hexane
	7.46	2,2-Dimethylpentane
	7.60	Methylcyclopentane
	7.91	2,4-Dimethylpentane
	8.18	2,2,3-Trimethylbutane
2	8.99	Benzene
	9.35	3,3-Dimethylpentane
	9.55	Cyclohexane
	10.23	2-Methylhexane
	10.32	2,3-Dimethylpentane
	10.47	1,1-Dimethylcyclohexane
	10.83	3-Methylhexane
	11.23	1-trans-3-Dimethylcyclopentane
	11.43	1-cis-3-Dimethylcyclopentane
	11.55	3-Ethylpentane
	11.63	1-trans-2-Dimethylcyclopentane
	11.78	2,2,4-Trimethylpentane
3	12.73	n-Heptane
	14.23	Methylcyclohexane
	14.53	2,2-Dimethylhexane
	15.27	Ethylcyclopentane
	15.49	2,5-Dimethylhexane
	15.65	2,4-Dimethylhexane
	16.09	1-trans-2-cis-4-Trimethylcyclopentane
	16.24	2,3,4-Trimethylpentane
	16.78	1-trans-2-cis-3-Trimethylcyclopentane
	17.05	2,3,3-Trimethylpentane
4	17.39	Toluene
	18.27	2,3-Dimethylhexane
	18.43	2-Methyl-3-ethylpentane
	18.84	2-Methylheptane
	19.69	1-Methyl-2-ethylcyclopentane
	18.98	4-Methylheptane
	19.23	1-cis-2-cis-4-trans-Trimethylcyclopentane
	19.50	3-Methylheptane
	19.77	1-trans-4-Dimethylcyclohexane
	20.73	1-Methyl-cis-2-ethylcyclopentane
	20.86	1-Methyl-trans-3-ethylcyclopentane
	21.08	1-Methyl-cis-3-ethylcyclohexane
	21.27	1-Ethy-1-methycyclopentane
	21.53	1-trans-2-Dimethylcyclohexane
5	22.43	n-Octane
	23.05	iso-Propylcyclopentane
	24.14	2.2.5-Trimethylhexane
	24.19	2,2,4-Trimethylhexane
	24,53	2,4,4-Trimethylhexane
	24.79	2,3,5-Trimethylhexane
	25.16	2,4-Dimethylheptane
	25.41	n-Propylcyclopentane
	25.73	1-cis-2-Dimethylcyclohexane
	26.00	1,1,3-Trimethylcyclohexane
	26.25	2,5-Dimethylheptane
	26.44	3,3-Dimethylheptane
	26.58	3,5-Dimethylheptane
	26.77	4,4-Dimethylheptane
	26.94	2,3,3-Trimethylhexane
	27.43	Ethylbenzene
	27.57	1-cis-3-cis-5-Trimethylpentane
	27.69	1,1,4-Trimethylcyclohexane
	27.88	2,3,4-Trimethylhexane
	28.15	3,3,4-Trimethylhexane
	28.42	m-Xylene
	28.54	p-Xylene
	28.74	2,3-Dimethylheptane
	28.84	1-cis-2-trans-4-trans-Trimethylcyclohexane
	28.95	1-cis-2-trans-4-cis-Trimethylcyclohexane
	29.16	3,4-Dimethylheptane
	29.31	3-Methylethylhexane
	29.68	4-Methyloctane
	29.81	2-Methyloctane
	30.56	3-Methyloctane
	30.93	o-Xylene
	31.75	1-Methyl-2-propylcyclopentane and 1-Methyl-trans-4-ethylcyclohexane
	31.98	1-Methyl-cis-4-ethylcyclohexane
	32.46	3,3-Diethylpentane
	32.89	2,2,6-Trimethylheptane
	33.17	1,1,2-Trimethycyclohexane
6	33.52	n-Nonane
	34.26	iso-Propylbenzene
	34.48	tert-Butylcyclopentane
	34.68	tert-Butylbenzene
	35.57	sec-Butylcyclopentane
	36.33	3-Methylnonane
	36.56	n-Propylbenzene
	36.83	n-Propylcyclohexane
	37.12	m-Ethyltoluene
	37.24	p-Ethyltoluene
	37.64	1,3,5-Trimethylbenzene
	38.20	2-Methylnonane
	38.36	o-Ethyltoluene
	38.75	3,6-Dimethyloctane
	38.75	1,2,4-Trimethylbenzene
7	40.32	n-Decane
	40.63	1,2,3-Trimethylbenzene
	41.57	4-Methyldecane
	41.94	sec-Butylbenzene
	42.45	n-Butylbenzene
	44.54	n-Undecane


1. Cyclopentane
2. 2,3-Dimethylbutane
1
2
1
2
3
4
5
6
7
5
10
15
20
25
30
35
40
45
30 °C, 5 min. hold
2 °C/min
80 °C
5 °C/min
10 °C/min
190 °C

TROUBLESHOOTING

The purpose of this information is to help you troubleshoot the performance of your chromatography - your system manual is an excellent guide to help you troubleshoot the performance of the system.

The separation of structurally diverse analytes is often complicated by chance coelutions with other analytes or with matrix related compounds. Often the column is blamed, but while such coelutions make analysis difficult, they do not necessarily indicate a faulty column, poor chromatography or method design. No single column or method will resolve all compounds that can be chromatographed, so selecting a column that matches the needs of the application is an important first step. Rather than attempting to modify a method to resolve coeluting peaks, selecting a column with subtly different selectivity can achieve this aim without significant changes to established methods, elution orders or run times.

The following are good starting points to not only develop the ideal method for your chromatography, but also a guide on where you can troubleshoot to improve your desired separation.

Phase Selection

- Select the least polar phase that will perform the separation you require. Non-polar stationary phases separate analytes predominantly by order of boiling point. Increase the amount of phenyl and/ or cyanopropyl content in the phase, and the separation is then influenced more by differences in dipole moments or charge distributions.

- To separate compounds that differ more in their hydrogen bonding capacities (for example aldehydes and alcohols), polyethylene glycol type phases are best suited, such as CBP-20.

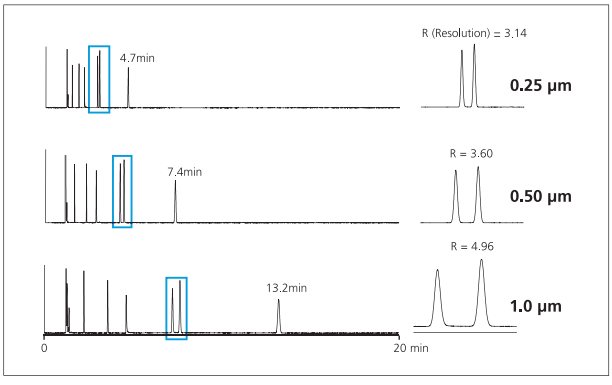
Column Diameter

- The smaller the diameter, the greater the efficiency, and better resolution. Fast columns (0.1 mm ID) are used for faster analysis because the same resolution can be achieved in a shorter time.

Film Thickness

- For samples with a variation in solute concentration, a thicker film column is recommended. This will reduce the possibility of broad overloaded peaks coeluting with other compounds of interest. If the separation of two solutes is sufficient and co-elution is still unlikely, even with large differences in concentration, then a thinner film can be used.

- The greater the film thickness the greater the retention of solutes, therefore the higher the elution temperature. As a rule, doubling the film thickness results in an increase in elution temperature of approximately 15-20 °C under isothermal conditions. Using a temperature program, the increase in elution temperature is slightly less.



Effect of Film Thickness.

- Maintain phase ratio among different ID columns to yield similar chromatography.

- Columns should be conditioned to the maximum continuous temperature unless specified. When conditioning columns with a film thickness > 1 µm at the maximum operation temperature, it is recommended to do the initial conditioning without a connection to the detector to minimize contamination from the siloxane bleed.

$$\beta = \frac{id}{4d_f}$$

where

β = phase ratio

id = column internal diameter (µm)

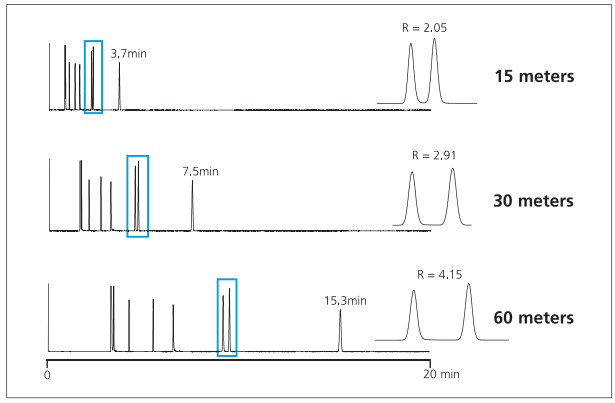
d_f = film thickness (µm)

Formula to calculate Phase Ratio.

Column Length

- Always try to select the shortest column length that will provide the required resolution for the application. If the maximum column length available is being used and resolution of the sample mixture is still inadequate then try changing the stationary phase or internal diameter.

- Resolution is proportional to the square root of the column efficiency; therefore, doubling the column length will only increase the resolving power of the column by approximately 40%.

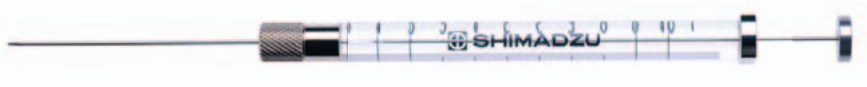


Effect of Length.

Injection

The function of the GC sample inlet is to introduce a representative portion of the sample as a narrow band onto the chromatographic column – failure to achieve this objective will significantly reduce the separation capability of the GC column. Because most samples are liquids, an essential feature of the common GC inlet type is that the sample and solvent are vaporized prior to reaching the column. These GC inlets are known as *'Vaporizing'* injectors. Below are several tips on the injector but you should also consider the function of the injection process and how it influences the chromatography. If the injection is not performed correctly, you will end up with poor accuracy and poor precision. If you have an autosampler fitted, you should follow the recommendations in your user manual to determine whether the autosampler is performing to specification.

The Syringe



- Syringe life is influenced by the quality of the sample and the frequency of use – a blunt needle will potentially deposit septa material into the inlet liner and severely impact your chromatography.

- For the best syringe life, ensure your syringe is rinsed five to ten times with clean solvent after use. Syringe washing also helps to eliminate carryover but remember to discard the initial washes.

- For optimal reproducibility and accuracy, the smallest volume injected from any syringe should be no less than 10 % of its total capacity, for example: the smallest recommended injection volume from a 10 µL syringe would be 1 µL.

The Injector

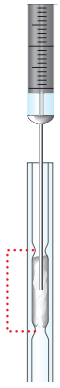
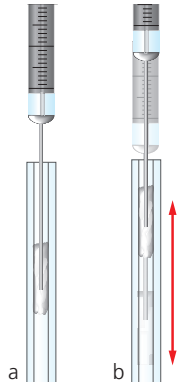
- If you are doing trace analysis work or working with high injection port temperatures, replace the septum regularly.

- If the injection port temperature is not specified in the method, 250 °C is usually the recommended temperature.

- Choose the appropriate inlet liner for your application – review the inlet liner geometries in this Product Guide (page 11) and suggested applications.

- If the inlet liner is not specified, it is recommended to use a FocusLiner™ with quartz wool and bottom taper.
  - The wool provides additional surface area for complete volatilization of the sample to minimize sample discrimination.
  - It traps non-volatile components and septum particles from reaching the column.
  - It wipes any sample from the syringe needle, thereby increasing reproducibility and preventing sample residue build-up at the septum.

- When choosing the inlet liner ensure the inlet liner volume is larger than the volume of vaporized sample. If the vapor volume exceeds the liner's inner volume, there will be an overflow of sample vapor from the liner, resulting in contamination of the inlet system which in turn leads to carryover (ghost peaks) and poor run-to-run reproducibility.

FocusLiner™	Conventional Liners
	
The two tapered sections secure the quartz wool plug effectively wiping the needle tip during injection. This results in improved reproducibility	Figure a Quartz wool plug is in the position to wipe needle tip. Figure b Quartz wool plug can be moved in either direction preventing the needle wiping or sample vaporization processes.

Liquid Volume (µL)	Inlet Temperature (˚C)	Inlet Pressure (psi)	Gas Volume (µL)
1	250	10	399
2	250	10	798
2	250	34.7	399
5	200	45	746

Dichloromethane as solvent

- The inlet liner is a consumable and its life is influenced by the quality of the sample and the frequency of use – once the inlet liner is contaminated with septa particles, it needs to be replaced. Recommended replacement is every 100 - 200 injections.

- When peak shape deteriorates, replace the inlet liner immediately and remove ~ 30 cm from the front of the capillary column.

- When replacing the inlet liner it is the ideal time to replace the septa and the inlet liner sealing O-ring.

GC Connections

Ferrules are the smallest, inexpensive and probably the most easily forgotten components that are used in every gas chromatograph. Yet, without ferrules, the leak-free sealing that is required at the detector and injector of a GC system would be impossible to achieve.

- Always cut the column **after** passing through a graphite ferrule – this eliminates the risk of graphite particles entering into the column and impacting your chromatography.

- Always re-tighten Graphite / Vespel® ferrules by ¼ to ½ turn after the first 2-3 oven temperature cycles – Graphite / Vespel® ferrules tend to "creep" during temperature cycling.

- For GC-MS connections always use SilTite™ metal ferrules to ensure a permanent leak-free connection.

High Baseline Level	Cause	Poor carrier gas quality
	Solution	Use high quality gas, install gas traps. Replace septa and insert a new inlet liner
	Cause	Exceeded the maximum temperature of the capillary column phase
	Solution	Lower the programmed maximum temperature
Loss of Sensitivity	Cause	System has become active
	Solution	Replace the inlet liner with a new deactivated liner, cut 50 cm off the front of the column and re-install
	Cause	Splitless conditions have changed
	Solution	Re-check solvent and method temperatures. Consider introducing an internal standard.
Loss of Peak Resolution	Cause	Manual injection technique or operator has changed
	Solution	Ensure technique is consistent
	Cause	Dirty column - if samples are dirty, non-volatile materials have deposited onto the column causing a change in polarity
	Solution	Cut 50 cm off the front of the column and re-install
Split Peaks	Cause	Poor injection technique
	Solution	Increase the manual plunger depression speed
	Cause	The column has been inserted too far into the injector
	Solution	Reposition the column according to the manufacturers recommendation
Fronting Peaks	Cause	Too much sample injected onto column
	Solution	Dilute the sample or increase the split ratio
Tailing Peaks	Cause	Glass inlet liner has active surface
	Solution	Replace with a fully deactivated inlet liner
	Cause	Graphite ferrule contamination in the start of the column
	Solution	Remove 5 cm off the front of the column and re-install
Broad Peaks	Cause	Split gas flow is too low
	Solution	Increase split flow or use the 'solvent effect' to focus peaks
	Cause	The column is contaminated
	Solution	Cut 50 cm off the front of the column and re-install
	Cause	Mass spectrometer sampling rate is too low
	Solution	Increase sampling rate or reduce the number of ions detected in SIM mode
	Cause	Co-elution of peaks
	Solution	Change the temperature program or polarity of the column
Shifting Retention Times	Cause	Leaking septum
	Solution	Tighten septum cap or replace septa
	Cause	Dirty column - if samples are dirty, non-volatile materials have deposited onto the column causing a change in polarity
	Solution	Cut 50 cm off the front of the column and re-install
No Peaks	Cause	Syringe is blocked or leaking around plunger
	Solution	Inspect syringe and change if damaged
	Cause	Column is blocked
	Solution	Cut 5 cm off the front and back ends of the column and re-install
Ghost peaks are appearing	Cause	Syringe has become contaminated from previous run
	Solution	Ensure syringe has been thoroughly washed with solvent between injections.
	Cause	Septum bleed
	Solution	Will appear as discrete peaks in a thermal gradient and disappear in an isothermal run. Replace septum
	Cause	A backflush event has occurred
	Solution	Inject twice the amount of pure solvent (repeat if necessary)

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